PREFACE

Biosensors – Topical issue

It is really interesting that such a simple and short word “biosensor” covers an amazingly diverse range of bioanalytical devices. The integration of various biorecognition molecules, transducing schemes and surfaces with immobilisation protocols offer almost unlimited variations of the biosensor construction or application of the device for analysis of a particular analyte.

A biosensor by definition is a device based on immobilised biorecognition elements in close proximity to or directly on the surface of a transducer (Labuda et al., 2010; Thévenot et al., 1999). However, in the literature the term “biosensor” is applied in a wider context: i.e. when a biorecognition element is applied for sensing purposes without fulfilling the requirement that the biorecognition element is immobilised; the term “biosensor” is used in this Topical Issue with this broader meaning.

The first biosensor was constructed by Clark and Lyons in 1962, when glucose oxidase (GOx) in combination with oxygen electrode was applied to measure glucose levels in blood (Clark & Lyons, 1962). Since then the field of biosensor was slowly evolving, when other detection schemes and biorecognition elements – besides enzymes and electrochemistry – found applications in biosensing. A major breakthrough happened in 1984, when the first mediated GOx biosensor designed to analyse glucose in blood was described by Cass et al. (1984) with the subsequent large commercial success of glucose blood testers. The second boom of biosensor development started around 1995, when both utilisation of self-assembled monolayers and nanoparticles or nanostructured surfaces for construction of biosensors was launched (Alivisatos, 1996; Daniel & Astruc, 2003; Love et al., 2005). Self-assembled monolayers of thiolated molecules on gold (Allara & Nuzzo, 1985; Porter et al., 1987) and quantum dots (Brus, 1984) were introduced a decade ago, but application of gold nanoparticles in biosensor preparation started almost immediately after introduction of Brust’s synthesis of gold nanoparticles (Brust et al., 1994). Initially Iijima in 1991 discovered helical microtubules of graphitic carbon, what we call now multi-walled carbon nanotubes (Iijima, 1991) and in two years single-walled carbon nanotubes were synthetized by Iijima and Ichihashi (1993). A decade later, an increased number

of papers was published, when carbon nanotubes became part of transducers or patterned surfaces in 2003. Another popular carbonaceous nanomaterial – a "hot nanomaterial" of today science – was discovered in 2004 by Geim and Novoselov (Novoselov et al., 2004), worth receiving the Nobel prize in 2010 for both scientists (Geim, 2011; Novoselov, 2011) and with subsequent wider application of graphene for biosensor construction starting in 2010. Thus, the growth in biosensor publications seems to be driven mainly by advances in material science affecting the development of new transducing schemes rather than by production of novel biorecognition elements including DNA aptamers, peptide aptamers, recombinant lectins, or antibodies. Similar trends can be observed in this Topical Issue showing value-added functionalities of the biosensors after integration of nanomaterials.

Pohanka reviews the application of enzyme biosensors for analysis of toxic and/or neurotoxic compounds by various reading schemes based on enzyme inhibition, interestingly with some of them being applicable for field assays (pp. 4–16). Dimcheva and Horozova summarise how nanoparticles can enhance performance of electrochemical enzyme biosensors by forming redox active interfaces and for direct electronic wiring of some redox enzymes (pp. 17–26).

Bertokova and co-workers describe the potential of bacterial *Gluconobacter oxydans* cells for manufacturing robust electrochemical microbial biosensors, also utilisable in bioprocess monitoring and for construction of biobateries (pp. 27–41). Application of nanomaterials such as carbon nanotubes, graphene and gold nanoparticles in microbial biosensor construction is discussed by Šefčovičová and Tkac (pp. 42–53).

Prospective novel biorecognition molecules such as green fluorescent proteins as reporter probes for analysis of various analytes based on fluorescence transfer to other fluorescent proteins, quantum dots or by fluorescence quenching is discussed by Heger and co-workers (pp. 54–61). Molecular beacons (short nucleic acid strand with a fluorophore–quencher pair attached to its ends) are another example of prospective novel biorecognition elements applicable for analysis of small and large biomolecules with potential in cancer and other disease diagnostics, as summarised by Stobiecka and Chałupa (pp. 62–76).

There is a block of 5 papers highlighting the need to develop novel ways of selective and sensitive analysis of prostate cancer (PCa) biomarkers – an effort currently funded within the European Commission Marie Curie Initial Training Network "Cancer Diagnosis: Parallel Sensing

of Prostate Cancer Biomarkers" (PROSENSE, www.prosense-itn.eu). Jolly and co-workers review the application of label-free methods of analysis of PCa biomarkers based on DNA aptamers, describing ways to enhance selectivity of analysis (pp. 77–89). Belicky and Tkac provide a review focused on the possibility of applying lectins for glycoprofiling of PCa biomarkers in order to enhance reliability of biomarker analysis in a label-free mode of operation (pp. 90–111). The final review in this section, provided by Filip and co-workers, gives a summary about integration of graphene as a signal amplifier for sensitive electrochemical analysis of biomolecules including various cancer biomarkers (pp. 112–133). Aliakbarinodehi and co-workers compare three different nanomaterials for construction of electrochemical biosensors for analysis of low-molecular weight molecule H_2O_2, a platform, which can be applicable for detection of cancer drugs (pp. 134–142). Finally Damborský and co-workers describe how surface plasmon resonance can be applied as an effective tool to identify prospective antibodies for analysis of PCa biomarkers (pp. 143–149).

Sýs and co-workers describe an electrochemical tyrosine-biosensor for analysis of vitamin E analogue using carbon nanotube-modified carbon paste electrodes for enhanced analyte detection performance (pp. 150–157). Maixnerová and co-workers applied mathematical modelling to describe the response of an enzyme biosensor for analysis of putrescine (a food freshness indicator), which can be applied to tune analytical performance of enzyme-based biosensors (pp. 158–166). Juřík and Skládal introduce an interesting way to analyse H_2O_2 and glucose by formation of a precipitate by the action of horseradish peroxidase and GOx with a possibility to regenerate the surface electrochemically (pp. 167–175).

Šefčovičová and co-workers describe an effective way to enhance performance of ethanol detection by a microbial biosensor, when nanoparticles are interfaced directly with bacterial cells (pp. 176–182). A whole-cell optical biosensor was applied by Solovyev and co-workers for analysis of toxic mercury by Hg^{2+}-induced bioluminescence of bioreporter *E. coli* cells working in artificial sea water (pp. 183–191).

Milosavljevic and co-workers describe synthesis of novel nanomaterial carbon quantum dots with different affinity towards ssDNA and dsDNA (pp. 192–201). Karastogianni and Girousi describe an ultrasensitive way for hepatitis B virus detection using Mn(II) complex-based electrochemical DNA biosensor (pp. 202–210). A novel controlled way to immobilise DNA

aptamer on the electrode surface via DNA tetrahedron was carefully characterised by a range of tools by Poturnayová and co-workers (211–226).

Since bovine serum albumin (BSA) is frequently applied for blocking the surface after immobilisation of a biorecognition element to resist non-specific interactions, the study from Xu and co-workers is interestingly showing non-specific binding of a dye on BSA most likely via hydrophobic interactions pointing out to the fact that this blocking agent might not work properly in complex samples (pp. 227–236). A short communication from Gutierrez-Sanchez and co-workers describes interesting application of electrochemically "wired" laccase enzyme on low-density graphite electrode as a sensitive oxygen biosensor (pp. 237–240). The final contribution comes from Trefulka and Paleček showing how useful voltammetry can be in distinguishing glycan isomers, a feature important for further development in the field of glycomics (pp. 241–244).

We hope that this Topical Issue on biosensors is a tasty appetizer for everyone interested in biosensor technologies, showing recent trends in the field and providing further application of biosensors beyond the commercially successful GOx-based ones.

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